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(54) SECURITY ELEMENTS AND SECURE DOCUMENTS

(71) We, E M I LIMITED, a British company, of Blyth Road, Hayes, Middlesex, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to security elements such as are usable for secure documents.

Security elements are bodies of material having a particular characteristic which can be detected when required so that the authenticity of the element or an object, such as a document, in which the element is securely incorporated can be verified. Typical uses are for incorporation in cards such as are usable as credit cards, in passes, keys and cash dispenser tokens, in passports and other documents and in valuable papers such as money and cheques.

It is particularly desirable that security elements should be secure, i.e. the characteristic should not be easily alterable, and should maintain the information or form applied to them during manufacture. One type of security element, proposed in United Kingdom Patent Specification 1331604, is a layer of magnetic material particles, e.g. gamma iron oxide, given a permanent pattern by selective alignment of particles in specific areas of the layer. This pattern is detectable by magnetising the layer and examining the remanence variation produced by the selective alignment.

Such an element provides a permanent record of information by suitable choice of areas to form a pattern in the layer, e.g. to represent a binary code, but the information density can be limited by the rheological 'flow' properties of the layer when wet during the alignment procedure. A permanent record is regarded herein as distinct from the erasable magnetic recording technique in that the record used in the security element does not depend on the magnetisation state of the security element but it is built into the structure of the element and only by alteration of the structure, causing damage to the element, can the record be altered, such alteration destroying the authenticity of the element.

It is an object of the invention to provide a security element specially suitable to carry a security pattern securely and capable of a high information density.

According to the invention there is provided a security element having an information bearing area constructed so that information is contained in said area in the form of a fixed, spatial pattern of coercivity variation, the element comprising a magnetically inert substrate bearing a thin film of a magnetic metal or a magnetic alloy having either spaced deposits of a non magnetic metal embedded therein or a relief structure at the surface thereof remote from the substrate, the upstanding parts of the relief structure being formed of the same said magnetic metal or magnetic alloy or of a different magnetic metal or magnetic alloy. Every part of said pattern may have a coercivity greater than 20 Oesteds.

According to another aspect of the invention, there is provided a method of making a security element having an information bearing area constructed so that information is contained in said area in the form of a fixed spatial pattern of coercivity variation comprising the steps of:

(a) providing a magnetically inert substrate,

(b) depositing a thin film of magnetic metal or a magnetic alloy on said substrate, and

(c) either (i) prior to deposition of said thin film depositing a non magnetic metal in spaced regions of the substrate or (ii) after deposition of said film forming a relief structure at the surface thereof remote from the substrate by either depositing a magnetic

metal or a magnetic alloy in spaced regions at the surface, or etching the film so that spaced upstanding regions are formed.

Embodiments of the invention will now be described with reference to the accompanying drawings in which:—

Figure 1 shows stages in the production of a security element,

Figure 2 shows a simple exemplary security element,

Figure 3 shows an outline of a production process of a security document secure card including a security element,

Figure 4 shows one form of security document ~~security~~ element reader,

Figure 5 shows graphs useful in understanding another form of security document element reader.

The security element is produced on a gas, plastics or other magnetically inert smooth flat substrate 1. Initially a coat of aluminium 2 is deposited (Figure 1a) by any suitable method such as evaporation, sputtering or chemical deposition. The aluminium coat may be initially continuous and then etched to a desired form or deposited directly in the desired form. The techniques of photolithography, masking and etching used in the micro-circuit art are suitable. A suitable desired form (Fig. 1b) is lands of aluminium coat 21, 23, 25 etc. between by channels 22, 24, 26 etc. revealing the substrate. The spacing of the channels is selected to represent information (as described below with reference to Figure 2) A typical channel width is between 0.05 and 0.2mm but clearly other sizes can be used, down to some 10 micro metre if required. The information is stored by the magnetic properties of the layer of material applied over the aluminium coat. Thus an evaporated overlay of a thin film of NiFeCo alloy, 3, typically in 65/15/20% proportions, has a low coercivity (e.g. some 2 to 3 Oersteds) indicated at "L", when deposited on the smooth substrate, and a higher coercivity (e.g. some 20—30 Oersteds) indicated at "H", when deposited on the relatively rough aluminium coat land surface. The different coercivity parts of such a permanently structured magnetic thin film are detectable by suitable means to recover the information.

Techniques of thin film deposition similar to those just described have been proposed by inter alia Spain et al, (IEEE. Trans. Mag. Sept. 1970 p. 451) Collins et al (Proc. IERE Conf. Video and Data Recording 1976, p. 79) and Battarel et al (ibid. p. 63). However these disclosures relate only to the production of structures of magnetically hard and soft material by which data represented by domain wall movement, can be erasably stored in the magnetically soft regions, of lower coercivity, surrounded by hard material which isolates the soft regions.

The information stored as domain wall presence and spacing is recovered by causing the domain walls to move along the magnetically soft channel in the hard material, in their information-storing arrangement for serial detection on passing a specific point in the channel (somewhat in the manner of a queue of people passing through a gate). The "hard" material merely defines the "soft" channel and of itself has no part in the storage of information. Thus the domain tip memory art does not assign any particular significance of the relative arrangement and form of the hard and soft regions. Further this are does not in any way suggest that the different coercivities could be used to form a pattern or that the pattern could be altered to record information in a permanent manner to provide a security element.

Figure 2 shows one practical form of a security element. Two rows of channels 201, 221 and a row of clock points 211, are provided in the aluminium coat 22 on substrate 21 and covered and filled by an alloy layer 23 as described above, to provide a permanent structure of coercivity differences. The pattern can be a security element of itself or additionally provide a secure information record. Assuming that a "channel" respresents a binary ONE and "no channel" (on a land) a binary ZERO then the form of Figure 2 could be read with reference to the clock points at 10011101, 11010011, i.e. two eight-digit binary numbers. The numbers could be used in a security system in known manner, for example as identity codes compared with keyed-in numbers.

The remanence change between the "hard" and "soft" materials may be much smaller than is general for aligned magnetisable oxides and in such a case appropriate techniques must be used to detect the magnetisation pattern. To provide a magnetically-readable security element the permanent structure could be arranged to be both eye-visible and magneto-optically detectable using e.g. the longitudinal or transverse Kerr or the Faraday magneto-to-optical effect.

If the security element is not to be visible it can be concealed by producing it on an opaque substrate and masking the surface of the element with a uniform highly-polished top surface of a non-magnetic material such as aluminium. When the element is eye-visible the visible pattern can be correlated with the magnetic pattern as a further check on authenticity.

Alternative techniques and materials for the construction of thin-film secure elements include the deposition of a "soft" magnetic film on a substrate, depositing a photoresist pattern mask and then depositing "hard" magnetic material through the mask, and the use of NiCoP (Hc some 3 Oe) and overlaid

CoP (Hc some 500 Oe). Deposition can be in a magnetic field (anisotropic) or isotropic. In the latter case NiFe soft films with Co or Co Cr overlays are suitable. Clearly the pattern can be formed by the high coercivity areas against a low coercivity background. More than two coercivity values can be used if required. The coercivities attainable with thin films are known to range between 0.1 and 200 Oersteds at least. The materials of higher coervicities, e.g. 30 Oersteds upwards for the "soft" channels, if magnetised longitudinally i.e. across the region boundaries, can be examined with conventional magnetic replay heads. For example an underlay, somewhat as in Figure 1, of tin to an electrolytically deposited CoP film can give coercivities of about 345 Oe and 830 Oe respectively for the channels and lands forming regions of the security pattern. Chromium underlay can produce a cobalt overlay with a coercivity of up to 900 Oe. For examination of such higher coercive values a unidirectional magnetic field, e.g. from a permanent magnet, is applied along an information record track formed by a succession of regions of alternating coercivity value placed side-by-side a conventional magnetic pick-up head, which may be of the type sensitive to flux or the type sensitive to rate of change of flux, is used to produce an output signal dependent on the flux emerging at the inter-region transitions.

While conventional flux sensors or rate of change of flux sensors can be used to recover information from thin films at such coercivities at the lower coercivities reliable recovery is made difficult by stray magnetic fields from adjacent regions which can shunt a field being searched for.

An alternative method of construction to that shown in Figure 1 is to apply a layer of thin film magnetisable material, e.g. cobalt, to a substrate, and then apply a mask defining channels over this layer. Further, similar, material is deposited in the channels. If the material is cobalt at 500 Angstrom chickness in each layer coercivities of 200 Oe and 400 Oe, for the thick parts, can be achieved. Alternatively a thick layer can be selectively etched.

If different materials are used for the two layers an intermediate coercivity is achieved where the layers are in contact and can undergo exchange coupling. Alternatively the same material deposited in different ways can be used. Suitable materials and techniques are known in the art, for example NiFe or NiFeCo over cobalt, and changing the evaporation conditions or the solution pH for electroless deposition.

As well as the coercivity variation referred to above the manner in which the thin film is formed can effect the remanence (retentivity) saturation inducation (magnetisation) or squareness ratio value of the material. For example when the value of remanence is varied from point to point a unidirectional field can be applied to the film to reveal the pattern as a variation of remanent magnetisation detectable by a magnetic pick-up transducer. Similarly the saturation magnetisation value could be used to form a detectable pattern. The squareness ratio, an indication of the B/M loop shape, is another detectable value by which the pattern can be defined and revealed by B/H measurements of the material. In the example above, with CoP overlaid on tin, a squareness ratio of some 0.65 is obtained.

A particular application for a security element as described above is in a pass-card, which might be part of a passport, or be an identity card.

A thin magnetic layer is deposited on a thin plastic sheet or web by vacuum or electroless plating. The first film layer is then plated to a depth to give a desired coercivity, which is generally inversely proportional to depth of deposition. E.g. for NiCoP plated film a depth of 0.075 micron gives a coercivity of some 1000—1200 Oe, while a depth of 0.15 micron gives a coercivity of some 600—800 Oe. A pattern of a magnetic property, e.g. coercivity, is then formed as described above either by plating around a resist pattern or by etching through a resist mask. To enhance the visibility of the finished element a copper or gold overall coat is now applied if required.

At this stage a pattern of a magnetic property has been formed in the structure of the thin magnetic film layer on the plastic film support. The pattern of the structure is defined by the resist and can be complex if required, i.e. a geometric pattern of lines or dots or bars, an intricate pattern as in a bank note or even letters or numbers, which may also identify the source and batch of material.

The magnetic film is now laminated to a carrier, e.g. one suitable for card manufacture, and is ready for further processing. The substrate may have an appropriate colour given to it in manufacture. Thus far the carrier is one of many all bearing a security element having a common pattern of a magnetic structure. The carrier is now made distinctive of an individual by removing material from the security element so as to record information in the patterned thin film. Suitable techniques are etching through a resist mask and laser evaporation. Whatever technique is used the security element has information recorded in it by removing parts of the element, e.g. in the shape of alphanumeric characters and also to reproduce a photograph and a signature. The photograph may be of the "half-tone" type using a grid of dots of different sizes to represent light and

shade.

A specific form to secure card production is now described with reference to Fig. 3. The secure card described is an identity card or passport which is to contain personal details of an individual, a photograph and a signature. The card is to be made secure by using a material having a permanent magnetic structural pattern, as described above.

The components of the card information are supplied by an applicant e.g. as a photograph of suitable size, a specimen signature and completed application form.

The apparatus in Figure 3 includes television cameras TV1, TV2 to which the photograph, PIC, and signature, SIG, are respectively displayed for conversion into time based video information signals INF1 and INF2. The details from the application form are entered via a keyboard KB for conversion into a time based information signal INF3. The information signal INF3 is displayed on a visual display unit, VDU3, for checking against the form. Similarly the photograph and signature are displayed on respective display units VDU1 and VDU2. Cameras TV1 and TV2 can be of the "zoom" type and have adjustable masking to cope with variation in signature and photograph size. The displays are examined by the machine operator and when satisfactory are permitted to move on to a control unit, CON, in the case of the keyboard information, and to a video handling unit, VID, in the case of the photograph and signature. The keyboard information can include a code number indicating the security element batch or other details.

A roll RS of the material including a thin film security feature described above is provided. The base material of the roll is a flexible plastics material such as a PVC/PVA copolymer, well-known in the security card art, on polyethylene tetra phtalate or a more heat-resistant material such as polymide. A heat reflective interlayer between the metal film and base material may be provided if required. Material is fed along a suitable feed path, e.g. conveyer belt or rollers, beneath a writing station WS. This station, together with subsequent lamination and checking stations LS and CS, is not described further as suitable mechanical arrangements are well known and their exact form is not part of the present invention.

At the writing station WS a portion of the roll RS is allocated as the eventual security card. A laser beam, of some 1 to 2 watts power, is generated in a source LAS and directed to an electromechanically controlled beam deflection device DEF. This is conveniently a mirror whose inclination is controlled in two directions by a control signal from the video unit VID. The beam intensity is also controlled. In this way the information in signals INF1 and INF2 can be cut into the thin film patterned security element on material RS. Typically a resolution on the card of some 30 lines/mm is desirable, and the system should be arranged with this resolution in mind. The control unit CON also supplies a signal derived from the keyboard entered information signal INF3 to control the cutting of this information into the film in alpha-numeric form, and in data form if required. The card, after all the information has been cut into the thin film, is moved to a lamination station, LS, at which a layer of transparent plastics film, e.g. 0.5mm PVC, is securely laminated to the cut surface to sandwich the thin film between the plastics layers.

This completes the making of the basic card but a check on the correctness of the information thereon is made by a magnetic sensor MAG and an optical or opto-magnetic sensor OS. These read the card and check the form of the security element pattern and compare the derived information with that used to compile the card. Conveniently a record of the VDU displays is made on micro-film in micro-film unit MFU and the micro-film is read into a comparator COMP to which the derived information is also fed. A YES/NO output indicates whether or not the card is satisfactory for issue. The micro-film provides a record at the issuing office.

In subsequent use the card has to be read at appropriate checking stations, e.g. frontiers, airports and the like. By this time the card may well be dirty or slightly damaged and therefore reading apparatus must cope with such cards.

To read cards produced as described above suitable readers, such as referred to in the checking stage above, are required. Devices proposed hitherto for thin films are not suitable although magneto-optic sensing of BH loops may be used to examine a security element for the presence of expected magnetic properties. Figure 4 shows a reader suitable, inter-alia, for films in the low coercivity range, e.g. 2 to 50 oe, such as the security element of Figure 2.

A simplified form of security element SE is shown having a film of magnetically relatively hard material, HM, on a substrate, ST, with areas of magnetically relatively soft material, SM. A permanent magnet PM is placed to saturate the film as the security element is moved in the direction of arrow A. An electromagnetic field is exertable by a conductor EM carrying a current IM in the direction shown by the arrow in Figure 4. This electromagnetic field opposes the permanent magnetic field to permit the hard and soft material to be distinguished. Light from a source LA is directed through a polarizer POL, of conventional form, to be reflected to

a detector DET. The light is directed transversely of the magnetic field of permanent magnet PM having poles N and S as in this embodiment the transverse Kerr effect is to be utilised. The intensity of the reflected light is affected differently by the magnetically hard and soft material, after magnetisation, and this difference is detected by detector DET to provide an output signal OP which, if required, can drive a display DISP which shows the recorded information or indicates the authenticity or otherwise of the security element under examination.

Magnetisation in a direction substantially parallel to the region boundaries, as shown here, is preferred as this is likely to produce less magnetic interaction between adjacent regions than other magnetisation directions, particularly for lower coercivity material. In this illustrated embodiment the magnetisation is perpendicular to the track direction but other directions are appropriate if the region boundaries are in another direction. To assist in the checking of a security document a reference area of each material coercivity value can be provided away from the pattern area.

In an arrangement based on the longitudinal Kerr effect the light source is placed in direct polarised light at right angles to the direction of arrow A, ie. parallel to the field of magnet PM, and an analyzer (not shown) is provided in front of detector DET to convert the variation of the plane of polarization, occurring in the longitudinal Kerr effect, to an intensity variation which is made use of above. The Kerr effect involves refelection of light. A similar technique but using transmission of light through the film is the Faraday effect. This requires a film thin enough to be transparent to light.

To carry out a check which will reduce the risk of simulation of a genuine security element the apparatus exemplified in Figure 4 can be used for two passes of the security element, a first one in which the visible pattern is examined by purely optical means and the nature of the pattern recorded and a second one in which the pattern is examined opto-magnetically so that a comparison can be made. Further checks can be made e.g. by altering the current in the conductor EM at a rate greater than that at which a pattern area passes beneath the detector thereby producing a variation in the detected light intensity for a pattern area.

In another check the permanent magnet PM is replaced with an electromagnet and its field is reversed to cause reversals in magnetisation of the hard areas HM which reversals are detected magneto-optically.

Magneto-optic detectors as described above can work effectively even through a protective transparent plastics layer over the security element.

Up to now the description has been directed to the manner in which information is permanently recorded on the security element. The nature of the information recorded, as well as the pattern used for the security element, can be selected by the system user. For example a passport system requires information that is internationally acceptable while the passport may also carry information of solely national or local significance. It is desirable that the internationally significant information shall only be applied by the country to which the information relates. Accordingly an internationally agreed but nationally aplied code format is required and this can be based on algorithms in turn based on the secure pattern in the security element. The data to which the algorithm is applied could also be derived from the details on the card, e.g. the form of the signature. The area from which data was derived could be indicated if required.

Furthermore the security elements may themselves all be different. While it may be easier in some cases to make all the elements in a batch the same a progressive variation may be included without difficulty. For example when a photo resist mask is used this may be printed with suitable radiation-opaque ink in a series of characters, e.g. a serial number, which changes at each printing action to produce individual masks, all distinct, when the photo resist is selectively removed in known manner. Apparatus for printing progressively changing serial numbers is well-known in for example, the ticket printing art.

Another form of reader is now described, which is particularly suitable for examining a magnetic material to determine whether or not particular coercivity values are present in particular proportions. For example a thin magnetisable film could be deposited as described above to have say 25% area of low coercivity channels, the rest, i.e. 75% of the film area, being of high coercivity. Clearly other ratios could be used. Alternatively a sinuous or other form of patterning of the two, or more, coercivities could be deposited and a particular examination track followed to derive a particular series of coercivity ratios as the examination track crosses the sinuous form.

Figure 5A shows a region R of thin film with a low coercivity channel CL in an area of higher coercivity material CM. An examination window, EX, defines the area of the region under examination along the examination track ET. Examination can be continuous or at intervals along the track as the window EX and region R move relatively as indicated by arrow D.

In the specific example of a security element considered, area CH has a coercivity of some 22 Oesteds and region CL a coerciv-

ity of some 3 Oesteds. Such a security element can be produced by forming a 200 Angstrom layer of aluminium on a glass substrate with the form of the higher coercivity area and depositing a Ni-Fe film of some 81% nickel and 19% iron over the glass and aluminium, by electroless plating.

The sinuous form shown has proportions that can be determined from window EX which is 1mm square.

When the film is electrolessly plated there is no pronounced easy or hard magnetisation axis in the film so orientation in the film is not critical.

Window EX is provided by a Kerr effect reader which has an output related to the coercivity, or coercivities, in the window area, when the material to be examined is caused to be cycled round its B-H loop by suitable magnetic fields, as is well-known in the art, and thereby the B—H loop can be plotted as the output of the reader related to the magnetic field intensities.

Referring again to Figure 5a consider the window EX moving along track ET through positions E1, E2, E3, and E4, A position E1 the material is wholly of higher coercivity and the B—H loop has a conventional form for such a material (see Figure 5b). At position E2 the window is crossed by a band of lower coercivity material, forming about 50% of the area, and the B—H loop has the unusual form shown in Figure 5b, referenced E2. At position E3 some 75% of the window area is of lower coercivity material and a different, unusual, B—G loop form is obtained, E3 in Figure 5b. At position E4 only 25% of the window area is of lower coercivity material and the further unusual B—H loop, shown at E4 in Figure 5b, is obtained. Figure 5c shows a conventional B—H loop for a window area wholly of the lower coercivity material. The form of loop obtained can be determined by using circuits such as peak detectors responsive to the axis values at which distortions occur in the basic B—H loop shape, e.g. as indicated at P1, P2, P3, P4 in Figure 5b. The detected forms can be identified either to simply establish that material of expected coercivities is present or to provide data from the position and sequence of certain B—H loop forms. Also the ratios between values such as points P1, P2, P3, P4 and the extreme values of the loop can be used.

The arrangements described above provide a wide range of techniques based on patterned thin films for the production and use of security elements and secure documents.

WHAT WE CLAIM IS:—

1. A security element having an information bearing area constructed so that information is contained in said area in the form of a fixed spatial pattern of coercivity variation, the element comprising a magnetically inert substrate bearing a thin film of a magnetic metal or a magnetic alloy having either spaced deposits of a non magnetic metal embedded therein or a relief structure at the surface thereof remote from the substrate, the upstanding parts of the relief structure being formed of the same said magnetic metal or magnetic alloy or of a different magnetic metal or magnetic aloy.

2. A security element according to Claim 1 wherein every part of said pattern has a coercivity greater than 20 Oesteds.

3. A security element according to Claims 1 or 2 wherein the thin film is formed of cobalt phosphorus alloy and the non-magnetic metal embedded therein is tin.

4. A security element according to Claims 1 to 2 wherein the thin film is formed of cobalt and the non-magnetic metal embedded therein is chromium.

5. A security element according to Claims 1 or 2 wherein the thin film is of cobalt and said upstanding parts are of nickel iron aloy or nickel iron cobalt alloy.

6. A security element according to Claims 1 or 2 wherein both the thin film and said upstanding parts are of cobalt.

7. A security element according to Claims 1 to 6 wherein the substrate is of glass or a plastics material.

8. A method of making a security element having an information bearing area constructed so that information is contained in said area in the form of a fixed spatial pattern of coercivity variation comprising the steps of:

(a) providing a magnetically inert substrate,

(b) depositing a thin film of magnetic metal or a magnetic alloy on said substrate, and

(c) either (i) prior to deposition of said thin film depositing a non magnetic metal in spaced regions of the substrate or (ii) after deposition of said film forming a relief structure at the surface thereof remote from the substrate by either depositing a magnetic metal or a magnetic alloy in spaced regions at the surface, or etching the film so that spaced upstanding regions are formed.

9. A method according to Claim 8 wherein said non-magnetic metal is deposited by applying a masking material to the substrate in regions other than said spaced regions depositing the non-magnetic metal in said spaced regions and removing the masking material.

10. A method according to Claim 8 wherein said non-magnetic metal is deposited by depositing a layer of the non-magnetic metal on the substrate, and etching the layer of the non-magnetic metal so that deposits thereof remain only in said spaced

regions.

11. A method according to Claims 8 to 10 wherein the magnetic metal is either cobalt phosphorus alloy or cobalt and the non-magnetic metal is respectively tin or chromium.

12. A method according to Claim 8 wherein the thin film is cobalt and the deposits at the surface thereof remote from the substrate are either nickel iron alloy, nickel iron cobalt alloy or cobalt.

13. A security element substantially as hereinbefore described by reference to and as illustrated in the accompanying drawings.

14. A method of making a security element substantially as hereinbefore described.

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Agent for the Applicants.

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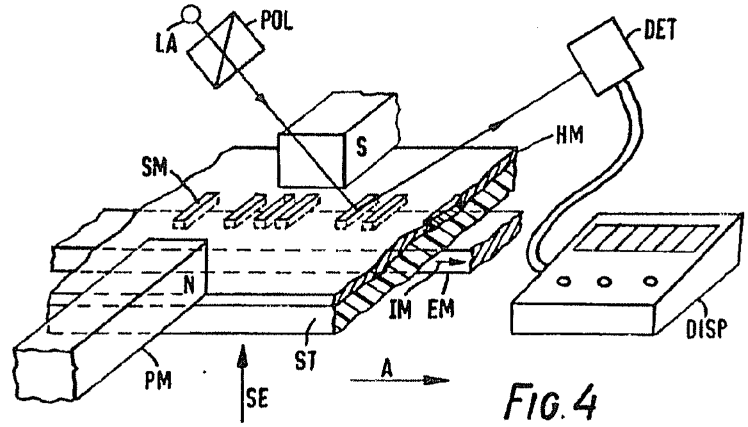


FIG. 4

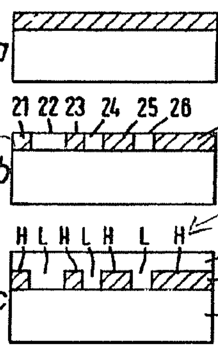


FIG.1

FIG. 2

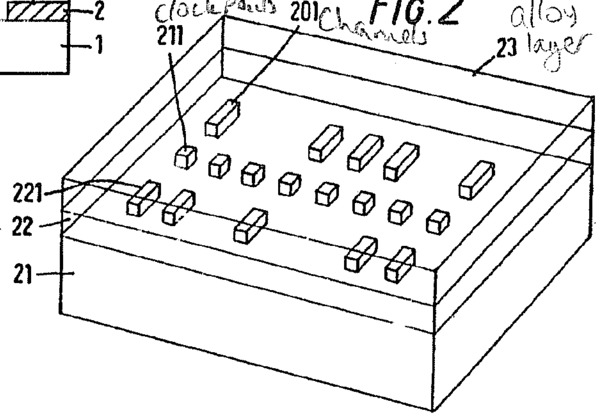
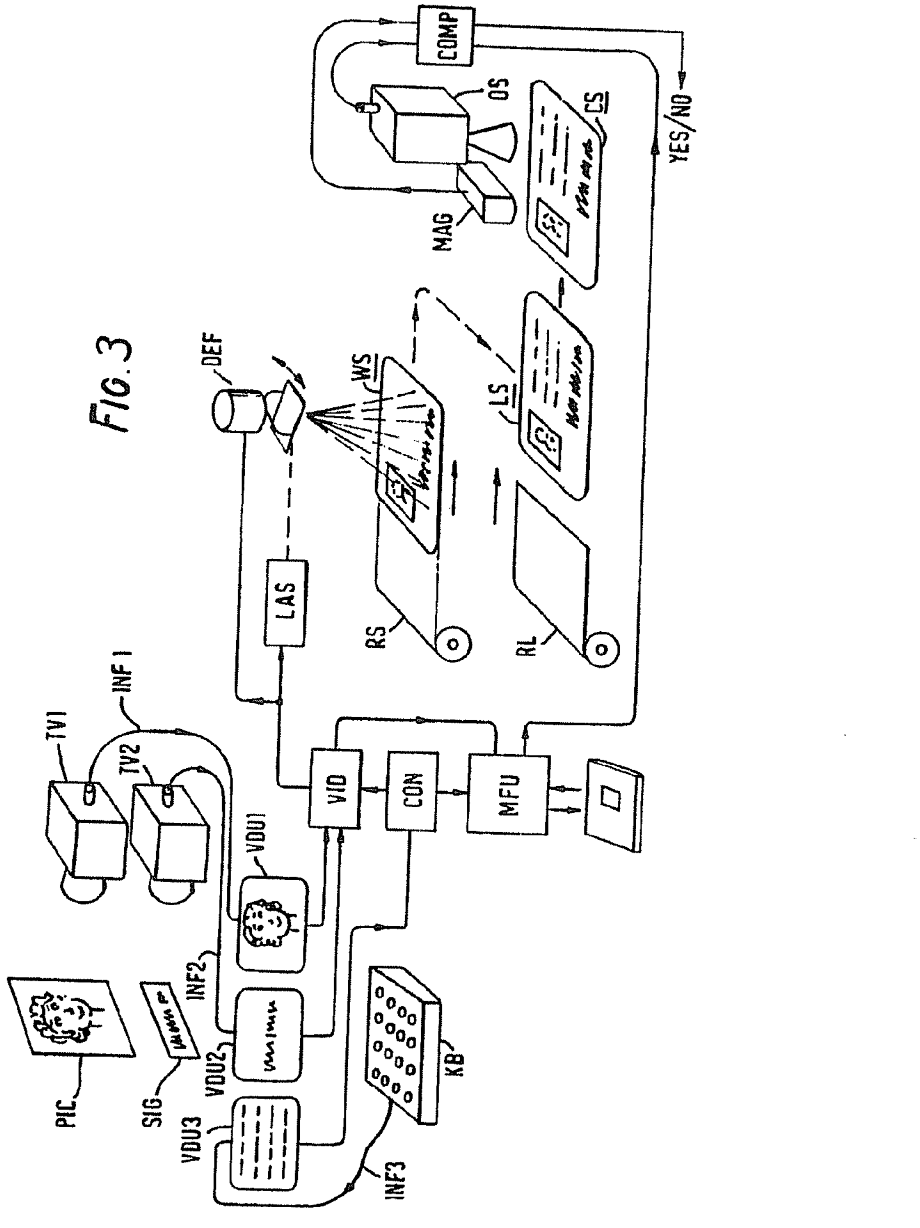


FIG. 3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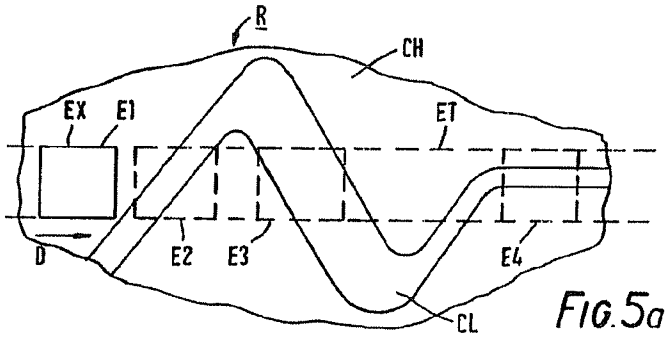

FIG.5a

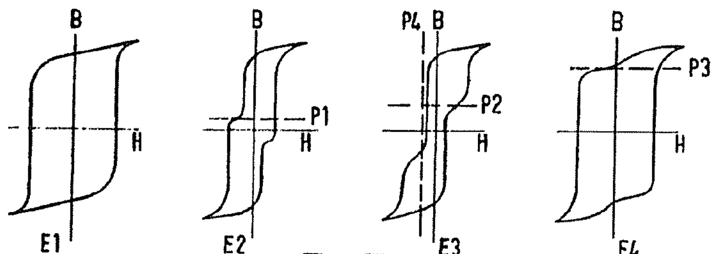

FIG.5b

FIG.5c